The Effects of Formative Evaluation and Remediation on Mastery of Intellectual Skills

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ABSTRACT

The purpose of this study was to test Gagné's hypothesis that attention to prerequisites should be more effective than repeated practice of a final task when learning intellectual skills. Ninety eighth-grade general science students studied self-instructional materials on the construction and interpretation of graphs. After each of three lessons each subject took a diagnostic test covering the objectives of the instruction. Subjects in Group 1 received additional instruction on prerequisites as remediation. Subjects in Group 2 received additional practice items as remediation, and subjects in Group 3 received no remedial activity. Students receiving remedial instruction did significantly better than those receiving only main-line instruction. Students receiving additional instruction on prerequisites did significantly better than those receiving additional practice items as remediation.

BLOOM (2) HAS SUGGESTED that all, or almost all, students can master what they are taught. The use of mastery learning strategies should enable up to 90 percent of the students to reach the same high level of achievement as the top third of those learning under traditional group-based instructional strategies. One procedure associated with mastery learning is for the instruction to contain frequent formative evaluation and remediation activities. If a student has not been successful in achieving mastery after initial instruction, then areas of weakness need to be identified and additional instructional pathways presented. This investigation was an attempt to identify some instructional strategies which may be effective in remediating detected learning difficulties.

Research on mastery learning offers some empirical support for the hypothesis that use of formative evaluation and remediation aids learning. Experimental studies (3, 8, 9) employing formative evaluation and remediation strategies yielded data indicating that the majority of students in each study were able to perform at the mastery level.

However, other research on mastery learning does not offer support for the diagnosis of learning problems followed by remedial work. Several experimental studies (6, 7, 11) employing formative evaluation and remediation strategies yielded data which failed to support the hypothesis. Closer examination of these studies suggests that the success or failure of a specific remediation strategy may depend upon the form the remedial instruction takes. For the most part, those studies that produced a significant improvement in learning employed additional instruction on prerequisites as remediation. Those studies which failed to produce significant improvement employed additional practice (more of the same instruction) as remediation.

Gagné (5) defines five domains or types of learning: motor skills, verbal knowledge, intellectual skills, cognitive strategies, and attitudes. He suggests that different instructional strategies and assessment techniques are appropriate for each type of learning. Thus he believes that an effective instructional strategy for teaching verbal knowledge, for example, may not work well for teaching motor skills. If the hypotheses of Gagné are correct, matching the remedial instruction strategy with the type of learning involved should produce significant improvement in learner achievement.

Of particular interest to this investigation was Gagné's hypothesis that the learning of intellectual skills requires prior learning of prerequisite tasks and that attention to prerequisites should be a more effective learning procedure than repeated practice of the task, a procedure recommended for learning motor skills. The purpose of this investigation was to determine if remedial instruction that focused on prerequisite skills would produce a more significant improvement in achievement of intellectual skills than additional practice items used as remediation.

Population and Procedure

The subjects involved in this investigation were 90 eighth-grade general science students who were members of four different classes taught by the same instructor. The subjects were ranked on their total score on the Arithmetic Skills Test of the Iowa Tests of Basic Skills. Random assignment within triads of the subjects produced three treatment groups of 30 subjects each. In addition to being assigned to a treatment group, each subject was also assigned to a level of the classification variable (Arithmetic Skills Test Score). The purpose of using the classification variable as a blocking variable was to increase the precision of the experiment (4). After examining the tabled values

for the optimal number of levels for a classification variable when used in blocking for precision, each treatment group (N=30) was divided into seven levels, six levels of four subjects each and one level of six.

All classroom activities during the investigation were directed by the regular classroom teacher. In introducing the activities, the teacher explained that he was interested in trying out a different form of instruction. The general form of the instruction was explained and the students told that they would be graded on their performance in the final examination covering the instruction.

During the experiment, each subject studied a block of self-instructional material on identifying variables, constructing graphs, and interpreting graphs. The instructional materials were designed to teach each of the tasks in a learning hierarchy, consisting of a terminal task and 13 subordinate skills (10).

During the first two classroom periods, all subjects completed a laboratory exercise and self-instructional material on identifying variables. This time was used to acclimate the subjects to self-instructional materials and diagnostic testing, consequently, no data were collected during this period.

Actual experimental treatment began on the third day. All subjects were presented a tape-slide program on constructing a table of data. At the end of the presentation the subjects took a diagnostic test covering the objectives of the instruction. At the end of the day the investigator collected the diagnostic tests from the classroom teacher, graded each, and assembled and delivered the remedial activity materials to the teacher in time for the next day's classes.

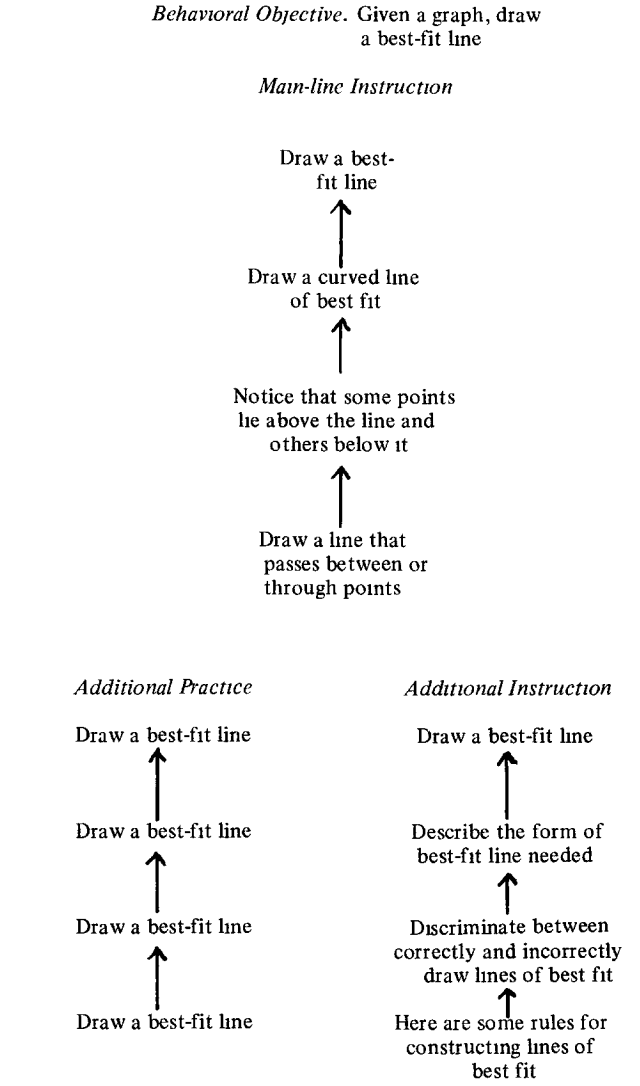
The results of the diagnostic tests were used to indicate which skills each subject had not acquired from the main-line instruction. Subjects in Groups 1 and 2 who were not successful in a particular test item received remedial activities. Group 1 received additional instruction on objectives prerequisite to those in the main-line instruction. Group 2 subjects received additional practice items similar to those in main-line instruction. Subjects in Group 3 received no additional instruction. All remedial activities were paper and pencil materials in which the subjects responded to a problem and received immediate feedback.

To further illustrate the difference between the two types of remedial work (additional practice and additional instruction on prerequisites), a comparison of the instructional tasks of main-line instruction, additional practice remediation, and additional instruction on prerequisite objectives is given in Figure 1. Each instructional task is represented by a phrase describing the directions given to the student.

This instruction-diagnostic test-remedial activity sequence was repeated three times (a total of six class periods) during the investigation. The criterion measure, consisting of 13 items covering the terminal task and 12 of the subordinate skills and requiring 40 minutes to complete, was administered to all subjects on the day following the third remedial period.

Since the diagnostic tests and the criterion measure were based upon behaviorally stated objectives which were the goal of instruction, the content validity of these tests was not considered a major problem. As Block (1) has pointed

Figure 1. - Comparison of the Sequence of Instructional Tasks for Main-line Instruction, Additional Practice, and Additional Instruction on Prerequisite Objectives



out, the validity of criterion-referenced tests rests upon the fact that they are based upon instructional objectives which define what pupils are expected to learn and, once the objectives are selected, the achievement criteria are determined. The reliability of the criterion measure (0.87) had been established in a previous study (11).

Results

The criterion measure scores in a randomized block design involving three levels of the treatment variable (type of remediation) and seven levels of the classification variable (math aptitude scores) were analyzed by factorial analysis of variance. The number of subjects, mean scores on the criterion test (maximum score = 13), and standard deviations are given in Table 1.

A priori comparisons among the treatment means were tested by partitioning the treatment sum of squares into orthogonal contrasts (see Table 2). Comparison 1 was

Table 1. - Central Tendency and Variability Data

Group	N	Mean	S.D.
1	30	8.83	3.10
2	30	7.60	3.94
3	30	6.93	2.73

between those subjects receiving remediation (Groups 1 and 2) and those receiving no remediation (Group 3). Comparison 2 was between those subjects receiving additional instruction on prerequisites as remediation (Group 1) and those receiving additional practice remediation (Group 2).

It was concluded that there was a significant difference in scores attained on the criterion measure which could be attributed to the use of remedial activities (Comparison 1) as well as a significant difference which could be attributed to the use of an alternative form of instruction (Comparison 2).

Discussion

In this investigation it was found that the use of an alternative form of instruction (*i.e.*, additional instruction on prerequisites) in an attempt to remediate learning errors produced a more significant improvement in achievement of intellectual skills than did the use of additional practice items as remediation. The hypothesis that identifying learning problems and providing additional instruction will improve performance was supported. Students who received both kinds of remedial instruction did significantly better than those receiving only main-line instruction. This implies that teachers interested in having students be successful in cognitive activities should identify learning errors and provide some sort of remedial activity.

The results also support the hypothesis that some types of remedial activity may be more effective than others for certain kinds of learning outcomes. Students receiving additional instruction on prerequisite objectives did significantly better than those receiving additional practice items as remediation. The results support Gagné's hypothesis that learning intellectual skills requires the mastery of prerequisite tasks and that additional study on the prerequisites will be more effective in remediating errors than additional practice of the final tasks themselves.

These findings have direct and important implications for classroom teachers and curriculum developers. It has been common practice in situations where the teacher or the curriculum materials provide remedial activity for students who have demonstrated learning errors to offer them additional practice or to recycle them through the main-line instruction. According to the findings in this investigation, these strategies may be helpful but may not be optimally effective in improving performance. It would seem more appropriate to provide an alternative form of instruction that provides additional instruction on prerequisite skills in attempting to remediate learning errors. A teacher attempting to individualize instruction in his classroom may wish to produce higher student performance in learning intellectual skills. To do so, he could select prepared curriculum materials that contain diagnostic tests and provide the student with additional instructional pathways or he might diagnostically test his students and select additional instruction to remediate detected errors in learning intellectual skills.

Table 2. - Partitioning of the Treatment Sum of Squares by Orthogonal Contrasts

Sources of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	F Ratios
Treatment	2	55.756		
Comparison				
1	1	32.938	32.938	5.818*
2	1	22.815	22.815	4.030*
Remainder	18	552.567		
Error	69	390.667	5.662	
Total	89	998.989		

* $P < 0.05$

REFERENCES

1. Block, J. H., "Criterion-referenced Measurements Potential," *School Review,* 79 289-298, 1971.
2. Bloom, B. S., "Learning for mastery," *Evaluation Comment,* 1 (2), 1968.
3. Collins, K. M., "An Investigation of the Variables of Bloom's Mastery Learning Model for Teaching Junior High School Mathematics, Doctoral dissertation, Purdue University, University Microfilms, Ann Arbor, Michigan, No. 72-1837, 1971
4. Felt, L. S., "A Comparison of the Precision of Three Experimental Designs Employing a Concomitant Variable," *Psychometrika,* 23: 335-354, 1958.
5. Gagné, R. M., "Domains of learning," paper presented at the American Educational Research Association Annual Meeting, New York, 1971.
6. Lawler, R. M., "An Investigation of Selected Instructional Strategies in an Undergraduate Computer-managed Instruction Course," Doctoral dissertation, The Florida State University, University Microfilms, Ann Arbor, Michigan, No. 71-24, 610, 1971.
7 Merrill, M. D., "Correction and Review on Successive Parts in Learning a Hierarchical Task," *Journal of Educational Psychology,* 56 225-234, 1965
8 Merrill, M. D., Barton, K., Wood, L. E., "Specific Review in Learning a Hierarchical Imaginary Science," *Journal of Educational Psychology,* 61. 102-109, 1970
9. Neal, E A., Foster, I , "An Experiment with Remedial Work in Common Fractions," *Elementary School Journal,* 29 280-283, 1928.
10. Okey, J. R., "Developing Competence in Process Skills," paper presented at the National Science Teachers Association Annual Meeting, Washington, April 1971.
11 Okey, J. R., Brown, J. L., Fiel, R. L., "Diagnostic Evaluation Methods in Individualized Instruction," *Science Education,* 56 207-212, 1972